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Innovative Intelligent Services for Supporting Cognitively Impaired Older Adults and Their Caregivers

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1. Introduction

1.1 European pilot project ISISEMD

ISISEMD project started in March 2009 is a European pilot project with the main aim to design, implement and test in real-life conditions innovative intelligent services for older adults with mild cognitive impairments and their formal and family care-givers (ISISEMD, 2009). Their ultimate goal is to improve the Quality of Life of the elderly and to help them to live more independently. The technology service platform is integration of systems from Hewlett Packard (Italy), Alcatel-Lucent (Italy), Converge ICT Solutions (Greece), Eltronic A/S (Denmark) and Socrate Medical (Italy). The service platform has been tested, validated and evaluated in four different European pilot sites (Frederikshavn in Denmark, Lappeenranta in Finland, Trikala in Greece and Belfast in UK) for a duration of more than one year and based on the outcome from the real-life operations and user feedback, it has been optimised, improved and adapted for diverse regional conditions. This has been a very challenging process because the user and functional requirements are very high w.r.t. intuitive user interface with minimum user interaction, diverse needs of the main user groups, personalisation needs, requirements for stable operation despite of the fact that it is a pilot system, but working in real-life conditions and exposed to interruptions in connectivity, hardware failures, human errors, etc.

1.2 Understanding the unmet needs of the end-user groups of ISISEMD services

According to the 2009 World Alzheimer Report, the number of people with dementia in Europe is conservatively anticipated to increase by 40% over the next 20 years mainly due to the increase in the ageing population (ALZ, 2009). This means that, due to limited resources,

there will be a significant challenge for the social care providers to meet their needs when the illness progresses. Currently, this group of citizens lives in the community and is being taken care of by their families which exposes them to care stress, social isolation, reduced employment and in many cases also leading to health deterioration. There are many types of dementia and for each person the disease develops individually. In general this group of older adults lacks structure of the day, their abstract thinking is drastically reduced, there are risks for home incidents from fire or a food forgotten on the cooker or they can get lost outside their home. All these risks prevent them to live independently and their family care-givers suffer a lot of stress and reduced quality of life. Their Quality of Life (QOL) can be maintained or increased and care stress can be reduced if intelligent technology services give the family care-givers a helping hand to notify about risks in the home or provide support information to the elderly person (EP) about the current day and time, upcoming appointments, etc. ISISEMD services have been initially designed for three main end-user groups – the older adults with mild dementia or mild cognitive impairments, their informal care-givers (partners, closest family, neighbours) and the formal carers.

The holistic approach of the ISISEMD services has a big potential for a positive impact but this requires "a smart system" with very high level of autonomous operation and intelligence of the services so they provide the exact type of home support needed for the specific dyad "elderly-family care-giver", with minimum interaction from the elderly and care-givers part. At the same time, the technology and the services must be "invisible" for the users and require very little or no user interaction at all.

The major contribution of ISISEMD project is that it aims at improving quality of life of fragile user groups by offering home support technology services in a holistic way, fulfilling most of their un-met needs. It involves all relevant end-user groups in the whole process of design, validation and assessment of the intelligent services in real-life conditions and in diverse regional settings. In this way it advances the developments one step closer in understanding the challenges that accompany the process of introducing Information and Communication Technology (ICT) services to older adults with mild cognitive impairments living in the community and their care-givers. Last but not least, it shares hands-on experiences and best practices.

1.3 Chapter outline

The challenges listed above were addressed by introducing intelligence in almost all of the services, in data and profile management, in the networking and in the integration and optimisation process. In this chapter we describe the final outcome of 30-month efforts, presented as follows: Section 2 presents a short overview of ISISEMD services. Section 3 focuses on highlighting the intelligent features in the service functionalities. Section 4 describes how ISISEMD project advances State-of-the-Art for intelligent systems and the advantages of ISISEMD system in comparison with other systems. Section 5 gives details how the services were piloted in real-life. Qualitative technical evaluation, service validation and user evaluation for satisfaction and acceptance were carried out and outcome from them is presented in Sections 6, 7 and 8 respectively. The positive impact from the use of the services is depicted with examples of "success stories" and users' statements in Section 9. The chapter is concluded in Section 10.

2. ISISEMD service platform – a short overview

The overall architecture of ISISEMD is composed in such a way that on one hand it fulfils the service requirements, and on the other hand it addresses the reality to make the different systems (also identified as x-Servers) to be integrated into a whole with a web-portal functioning as a common entry point for the ISISEMD system. The portal is the actual single point of entrance into the ISISEMD system and is the component responsible for the management of the users as well as the association of users with services and other users. It contains various functional sub-components such as a User Management module, an Authentication and Authorisation module, a Logging module, and a Reporting module. At the user side, the central unit is a computer with a touch screen, which is called Carebox. High level architecture of ISISEMD platform is presented on the figure below.

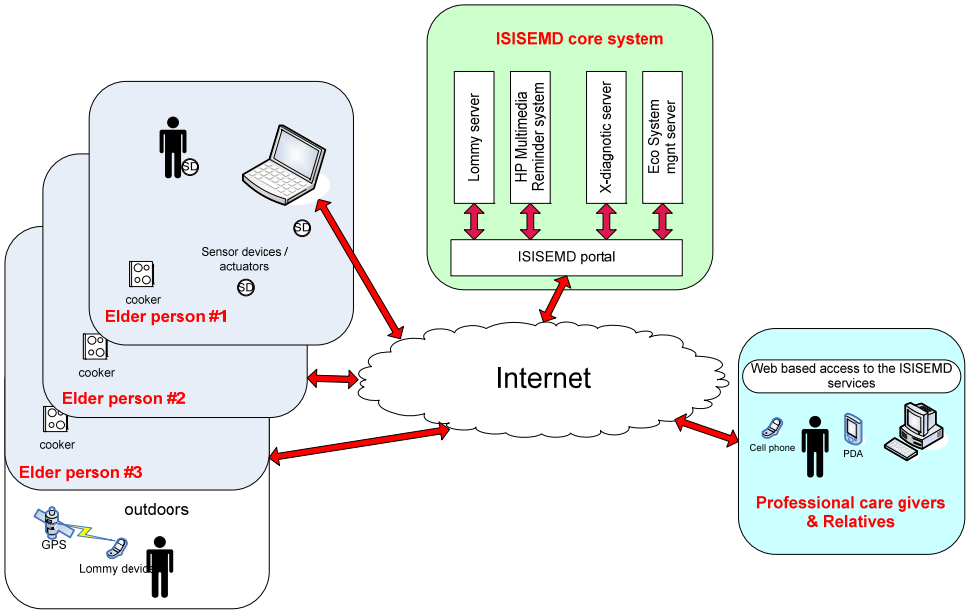

Fig. 1. High level architecture of the ISISEMD service platform

ISISEMD services for cognitively impaired adults include (Table 1): home and personal safety observations; reminders and prompts for basic daily activities – pre-defined reminders exist but there is also the possibility to set up and show personalised "free text reminders"; services for cognitive stimulation (Memory Lane shows a picture slide show on the Carebox and Brain Games that can be played on the Carebox); video communication service with care-givers; location service when the person is out of the home with the help of a simple GPS device called Lommy; emergency contact button in the home (Help button on the Carebox touch screen) and outside the home (panic button on the GPS device).

ISISEMD services for the formal (FCG) and informal care-givers (ICG) include: alerts, notifications, and alarm services which are distributed by mobile phone or email; an overview of daily activities shown on the portal; video-call service for communication with the elderly;

lifestyle pattern information over a period of time and remote doctor service. The added value for the informal care-givers relies on the fact of reducing the care stress towards an elder person and of being able to have the ability to receive information about potentially dangerous situations for their relative. This gives the feeling of safety for the beloved people and to be able to use the services without having any extensive knowledge on ICT - for instance a relative who takes care for the partner can be also a senior citizen. More details for the characteristics of the end-user groups and the added value for them from using the ICT services are provided in (Mitseva et al., 2009).

Service type	Service name	Validation status
Home safety	Cooking monitor	Validated during the real-life pilot operation
	Smoke/ Fire detection alarm	
	Kitchen/Bathroom flood detection	
	Fridge door alarm	
	Leaving bed during night for long time	
	Wake up sensor	
	Intelligent front door	
Structure of the day and contact to informal care-givers in case of emergency	To Do List, Calendar, Time/Date	Validated during the real-life pilot operation
	Help/Contact request on the touch screen	
Cognitive stimulation	Brain Games	Validated during the real-life pilot operation
	Memory Lane	
Communication with care-givers	Videophone	Partially validated during the real-life pilot operation
Communication with health and care professionals	Remote Doctor	Demo evaluation
	Medication Manager	Not validated during the real-life pilot operation
Outdoor safety	Outdoor positioning	Validated during the real-life pilot operation
	Panic button with outdoor position	
	Fall alarm outdoor	
Professional care-givers support	Lifestyle Pattern	Partially validated during the real-life pilot operation

Table 1. List of ISISEMD services

Similarly, the ISISEMD platform adds value to the social care providers. They can unobtrusively monitor some activities that take place in homes and outdoors through general purpose, off-the-shelf devices. They have the ability to save travel time for performing unnecessary homes visits to the clients and to communicate remotely with the elderly clients using video-call service, and in this way, there is more time for care for more clients.

The table above gives an overview of the ISISEMD services. In the following sections we focus on the intelligent features of the service platform.

3. Intelligence in the service platform

One of the advantages of the ISISEMD system is the hidden intelligence in the provided services. The basic idea is to abstract the services and make them transparent so the end users cannot actually realise the system complexity as they may not have much knowledge on ICT and this is not expected either. Drawing on this, the services act and pro-act in such a way that they are to define any critical circumstances that might occur before these actually happen and thus, they try to anticipate any consequences (e.g. the relatives of a person will receive a notification if the person is cooking for longer time than expected, anticipating thus a possible danger of having a fire in the home). This intelligence is possible to implement through a high-end home automation system identified as the Ecosystem.

3.1 Home safety services

Home safety services consist of sensors for monitoring the safety in the home environment. They function through sending email/sms to care-givers, posting alarms or notification messages on the web portal in cases of alarm events from the intelligent front door sensor, cooking monitor, fridge door sensor, fire/smoke sensor, flood detection sensor, bed sensors and/or motion detectors.

The Ecosystem part of the Carebox technically consists of a virtual machine that runs a local instance of an Ecosystem Domotics server, which is a reduced set of services and processes tailored for the specific requirements. This server is responsible for monitoring and responding to events from the various input sensors in the patient's home. A special ISISEMD-specific service installed on each Domotics module is responsible for relaying those events up to the central X-Server hub process on the portal-side of the server to be evaluated and acted upon if required. Through this fact, a delegation of intelligence is possible to the first level of reaction so as to increase the efficiency of the whole system.

An example of domotic service operation is explained by the control of the home cooker - the event is triggered by the fact that the person turns on the cooker. This activates an event of setting the appropriate timers that will monitor the duration of the cooker being on. Alert messages will be issued accordingly and the measures will be taken in such a way that will prohibit an accident and preventing fires, etc. Respective workflows are triggered by events captured by other sensors.

Elderly person is staying at home alone and the home is equipped with the aforementioned home automation services for preventing the events that have been mentioned. The services are pre-configured and running in the background without disturbing his daily life. Whenever the events that trigger the services are activated, the workflows will start-up to deliver the services.

3.1.1 Cooking monitor service

The purpose of having installed a cooking monitor in the elderly peoples' homes is significant for the safety of receiving an alarm in case of having forgotten to turn off the

cooker. If an elderly has forgotten to turn off the cooker, a care-giver will be able to view the current status displayed on the portal when logging in. For instance, on the service page on the portal, it will be displayed if an elderly has "started cooking", "cooking on" or "not cooking" and the last time when this event took place will also be illustrated. If for instance the cooker has been on for a while or for too long, the system will send the information containing an alert message (email/sms) to the care-giver. At the same time, at elderly's home, a voice message will be played to the elderly person from the Carebox, and a blinking message will turn up on the top part of the Carebox screen to warn him/her about the forgotten activity. The duration for cooking before receiving an alert is to be adjusted depending on the "life style pattern" of the specific elderly person. For example, the time for the duration of a cooker being turned on for a while can be adjusted before it is to trigger an alarm to care-givers. The voice and text message for cooking for a while is a prompt for the elderly to react, defined as first level reaction. Then if the system detects that there is no response from the elderly, an alarm could be sent to care-giver for example that the cooker has not been turned off for more than a pre-defined period of time – this is characterised as the second level reaction. All these events, communicated as cooker on, cooker off, message for cooking for a while or for too long, are posted on the message board on the web portal for overview purpose of the daily activities. The workflow for this service is depicted on Figure 2 below.

Depending on the preferences of the regional care provider and the family care-givers, the cooking monitoring service can work with either one of the three installations - one temperature sensor, with two temperature sensors or with a power relay. In case of two temperature sensors, a threshold for temperature difference can be adjusted from the web portal.

3.1.2 Smoke/fire detection service

The purpose of the smoke/fire alarm is to send information for smoke or fire alarm to the web portal. Furthermore, the system notifies the elderly person on the Carebox about the dangerous situation. At the same time it notifies the caregivers by SMS or email. If care-giver accesses this service, a care-giver can see if a fire alarm is in progress, the last time when a fire alarm may have occurred, and if so, the care-giver can view the time when it ended (i.e. it was reset). All these events are posted on the web portal in the list with recent events so the care-giver can see them. If there is event "smoke/fire alarm ON", at the same time the system shows a blinking message on the top line of the Carebox and is "telling" to the elderly person that there is smoke/fire detected in the home and he/she needs to react. This notification is repeated periodically on the Carebox until the event "smoke/fire alarm OFF" is detected by the system. Improvement suggested during the real-life pilot operation for the smoke/fire alarm service was to send one additional SMS - initially the service was designed to send one SMS in case of "alarm on" event but there was a need for similar notification SMS for "alarm off" event and this was implemented. This was needed because of some cases with false alarms during the test period and also due to the fact that very often more than one relative receives SMS alarms but depending on their agreement, one is to react in case of incident. The second SMS was to inform all of them that there is no more danger.

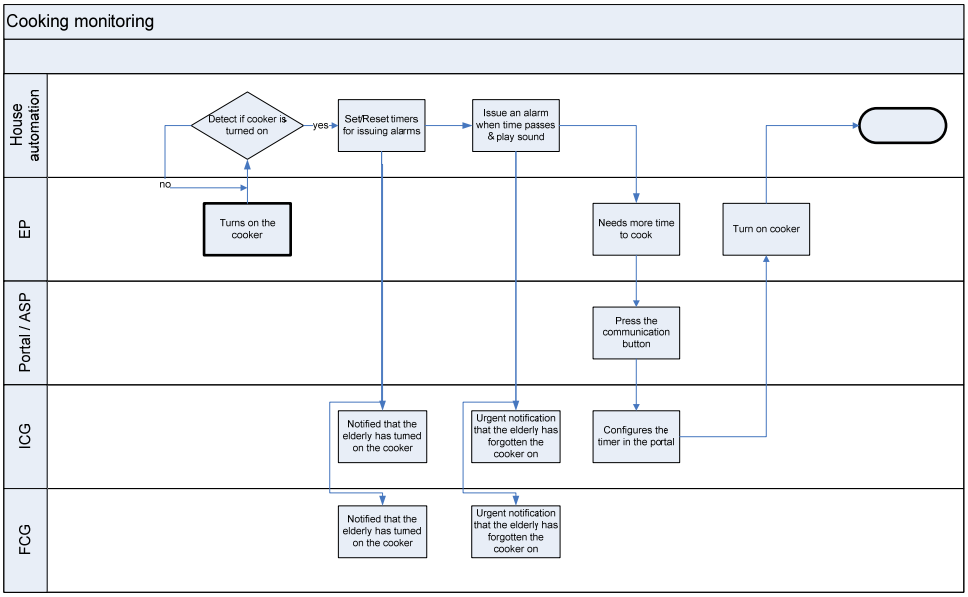

Fig. 2. Workflow for service "cooking monitor"

3.1.3 Fridge door service

This service monitors the door of the refrigerator. Once the elderly person opens the refrigerator door, the system will wait for it to be closed after a certain predefined time period. If it is not closed in the specified amount of time, an alert will be issued:

- Letting a caregiver know if the door has been forgotten open for too long – by email or SMS.
- The open, close or alarm events will be posted on the portal
- The following parameter can be adjusted: Time duration, since the fridge door was opened, after which to send an alert to a caregiver that the fridge door has probably been forgotten open (specified in minutes).

If there is an alarm situation, the system shows a blinking message on the top line of the Carebox and is "telling" to the elderly that the fridge door has been opened for too long and he/she needs to react. This notification is repeated periodically on the Carebox until the event "fridge door closed" is detected by the system.

3.1.4 Bed service

Alarm is triggered if an elderly has left the bed for a long time during the night. Furthermore, this service allows a caregiver to be notified about disturbances or significant alterations in the patient's sleep pattern. From the service page, a caregiver can view whether the elderly person is in the bed or not, the last time the patient sat or slept on it, and the last time the elderly person got up from the bed.

The service can send the following alerts:

- If an elderly person has been on the bed too long time (a case in which the care-giver assumes that the elderly might be experiencing difficulty or health issues).
- If an elderly person has left the bed too long time during a certain period of time (such as night time) and which might mean that elderly person has fallen down.

The following three parameters can be adjusted:

- Time duration after which an alarm is issued, if an elderly is still in bed (specified in minutes)
- Time duration, during "night time" (see next parameter) after which a care-giver should be alerted if the elderly is out of bed.
- The start and end times of the 'night time' period. These two times tell the service what time is considered to be "night time", i.e. the period during which the care-giver wants to receive alerts if the elderly leaves the bed for a certain time (see previous parameter).

Example of these parameters is when the system raises an alarm if the patient is in bed for longer than 10 hours, and also in case the patient left the bed between 10pm and 6am for longer than one hour (specified as 60 minutes). Since very often the elderly person takes a nap in the afternoon, it was suggested by the regional partners that additional time period of afternoon sleep is defined, similar to the night-time sleep period. However, this could not be implemented in the time frame of the project.

3.1.5 Intelligent front door service

This service monitors the status of the elderly's front door and monitors the presence of the elderly in the home with the help of motion detection (and bed sensor information if such a sensor is installed). On the main service page a care-giver can see the status of the front door, as well as the last times it was opened or closed and the last time a movement was recorded in the home.

Line for current status also shows whether the system has assumed that the elderly is present in the home or not at this moment. The system makes this conclusion by monitoring the various sensors, such as cooking sensor, door activity sensor, fridge door activity sensor, motion detection activity sensor. Each time when an activity is detected by one of these sensors it assumes that the elderly is active and in the home. The service also monitors the bed status (if bed sensor is installed), so that if there is no activity but the elderly is sleeping then this too will indicate an elderly's presence in the home. If there is no activity on any of these sensors for a certain amount of time (customisable from the service screen in the web portal) then the system will report to care-givers that the elderly is absent from the home and will make notification accordingly. Alerts are sent if the front door has been opened for more than a certain amount of minutes, when an elderly is absent from the house for certain hours and if an elderly is assumed to be absent from home for too long time.

The front door alarm is a service that can be customised depending on the elderly life pattern. For this purpose, four parameters can be adjusted according to:

- Time duration after which the front door will issue an alert if it stays opened, specified in minutes.

- Time duration of inactivity that determines when the system decides that the patient is out of the home (see above description).
- Time duration after which the system will issue an alert if the elderly is considered inactive (see above description), specified in minutes.
- The start and end times of the "night time" period. These two times tell the service what time is considered to be "night time", i.e. the period during which the care-giver wants to receive alerts if the patient leaves the home.

During the pilot operation, there were some cases when bed sensors could not be used – for example the elderly sleeps on a folding sofa and a bed sensor cannot be installed or if the elderly does not want to have a bed sensor installed due to some health problems. In this case, the current settings of this service cannot allow for optimal operation during the night period. Therefore, one of the suggestions for improvement was for the intelligent front door service to work without considering information from the bed sensor during the night. However, the final solution could not be implemented by the end of the project; instead a temporary solution was found for the special cases.

3.2 Carebox for the end-user

The only visible interface toward the ISISEMD platform for the elderly persons is the touch screen-enabled device installed in their homes. The motivations behind the selection of such kind of device are multiple:

1. First of all, it is very difficult for people with cognitive impairments to learn how to interact with new technologies: since they tend to forget what they already know, it would not be effective at all introducing in their life new elements that are not familiar to them
2. In addition, for the same reason described above, the need for direct interaction between them and the system must be reduced to the minimum, if not eliminated
3. Finally, in the cases where such interactions cannot be eliminated, they must be performed in the simplest and more intuitive modality possible

The touch screen-enabled device selected for providing the ISISEMD services for the end user can fulfil the above-mentioned requirements in the way that:

1. The shape, dimensions and aspect of the device are indeed identical to the ones of a television set, an appliance whose diffusion, in the last fifty years, has reached almost every home (at least in the developed countries). This means that it can be introduced in the elderly persons' homes in a natural manner
2. The device can provide different interaction levels; the level for each end-user can be configured (at any time and remotely) by a care-giver based on the level of impairment. In the simplest configuration, no interaction possibilities at all are provided
3. The touch screen modality is currently the simplest and more intuitive technology available to interact with a computing system, which requires a very low level of training and cognitive capabilities

From a functional perspective, the device plays several roles:

- Acts as the collector for all the messages that must be shown to the end-user. Running an intelligent software module, it makes decisions on when a message must be

delivered and, based on several static and dynamic parameters - such as the user profile, the configuration made by the care-givers, the importance of the event to be notified, the surrounding context - what the proper formats for the delivery are (e.g. only text, text and audio message, text and sound, etc.)
- Allows the user to proactively use the platform by pressing a single "soft" button on the graphical user interface (GUI) to ask assistance from the care-givers. This can be accomplished by pressing with a finger on a help button which triggers the sending of notification messages in the form of SMS or email, or a button for receiving a video-conference session
- Stimulates the cognitive capabilities of mild-dementia affected people by displaying information that helps them in maintaining the structure of the day (e.g. date and time) and the memories (e.g. slide show of personal pictures meaningful to them). Provides possibility to the elderly to confirm an activity by pressing a single "soft" button on GUI if elderly is able to interact with the system

The intelligent software module running on the device is constantly in communication with a central server module and is capable to enable/disable in real-time every single service provisioned, based on the configuration decided by a care-giver. Accordingly, it repaints the GUI elements displayed on the screen adding or removing them dynamically, for example by adding a new upcoming event in the list of "Next events". In addition to this, the module constantly considers the user context, leveraging the device equipment (e.g. the embedded web camera) or data coming from other devices (e.g. domotic sensors) and takes decisions based on the current situation.

Here follow some examples:

- During the night time the system enters an energy saving mode by turning off the screen. Such modality is interrupted (the screen is displayed again) if movement is detected in the surrounding by the context monitoring module
- Multimedia alarm messages related to dangerous conditions in the home (e.g. a fire alarm or a cooker left on for a long time) are played on the device speakers and shown on the device screen on behalf of the domotic module. In this way, the elderly person can react to the situation (e.g. switching off the cooker) or, in case he/she does not within a pre-configured timeframe, alarm messages are sent to the care-givers and relatives in form of SMS and email
- In case of external conditions that temporarily prevent the module to provide some of the functionalities (e.g. instable network connection), it changes the display layout showing proper notification messages which inform of the unavailability of one or more services. At the same time, a server side module is capable of detecting the error conditions and of alerting the proper actors (for example the service support team) to take action. As soon as the error conditions disappear, the module automatically returns in full-operation mode. Notifications are sent also to the care-givers.

The layout of the GUI displayed on the Carebox and the related contents are strongly dependent on the settings made by the care-givers for each end-user. As already mentioned, the system is quite flexible, so that the care-givers can enable/disable at runtime a different set of services for each user depending on the level of cognitive impairments. Such configuration is made by accessing the web portal. Anyway, there is a core set of essential

services that are provisioned to all the end users (since they are strictly related to their safety) that require the delivery of notifications to them by means of the Carebox. Such notifications can be divided into two main categories:

1. Messages coming from the domotic sensors, which are strictly related to the end-user safety
2. Messages configured by the care-givers on the web portal which should help the end user in maintaining the structure of the day

The configuration for messages of type 1 is made by the care-giver by accessing the "Domotic services" section of the web portal, and by filling the proper settings as described in the previous section on domotic-related services.

The configuration for messages of type 2 is made by accessing the "To Do List" and "Calendar" section of the web portal. This section provides the caregivers with a huge set of possibilities for configuring and scheduling the prompt messages that must be shown on the screen of an end user:

- It is possible either to choose among a pre-defined set of commonly used messages or to create custom ones, so called "free text reminders"
- It can be selected the format for the notification: text, audio or both
- It is possible to associate a sound to the message, to catch the end-user´s attention
- It can be defined how many times the message must be played and shown before disappearing from the screen and the interval among repetitions
- The system allows to configure every desired scheduling pattern for the message:
  - One-time only at a specified date and time
  - Recurring message (every day, once a week, once a month, once a year at the same time)
  - Recurring only in specified date ranges
- It is possible for care-givers to specify, for each configured reminder, if a corresponding confirmation button must appear on the Carebox screen together with the message. If the message is not confirmed (e.g. the end user does not press the confirmation button), notifications are sent to the caregiver by SMS and email
- In case the reminder requires confirmation, the care-givers can define on the service page some rules for how and when they want to receive SMS or email messages in case of missing confirmation

Every Carebox is constantly in communication with the server-side module handling the configuration of the reminders and updates in almost real time for every modification, which affects the set of messages to display.

3.3 Knowledge and data management

In general knowledge management comprises a range of strategies and practices used in an organisation to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insights and experiences comprise knowledge, either embodied in individuals or embedded in organisational processes or practice.

In ISISEMD platform knowledge is being used in order to assist the care-givers to take the appropriate decisions. Knowledge comprises the aggregated information gathered from

various sources (sensors, log data, events, etc) and is being considered in the service provisioning.

A dedicated service directly related with this is a Lifestyle pattern service. This service is not based on one workflow. It is a rather complex service that has to do with monitoring and logging the various events that happen in the domotics and Carebox environment of the elderly and in the sequel applying Business Intelligence in order to derive the patterns and the life style of the elderly. Based on this, important conclusions can be made for further optimisation of the home automations and care-giver strategies can be better adapted.

3.4 System optimisation for real-life operation

During the pilot operation, diverse interruptions of the normal system operation were observed due to some real-life factors, e.g. internet disconnection problems, high sensitivity of the touch screen, etc., all of them leading to generating false alarms or service unavailability. Therefore, additional layer of intelligence was introduced by fall back solutions and allowing for a higher tolerance to interruptions without jeopardising the safety of the end user. Also in case of planned technical maintenance operations, messages are sent to all care-givers and in case of portal or x- servers' unavailability, a notification is sent to the technical support team.

4. Advancing state-of-the-art for intelligent systems

4.1 Service oriented architecture

One of the major challenges for ISISEMD platform is the sustainability in the long-run, which can only be guaranteed if the technology can support a long term evolution, considering the user needs and the competition. Therefore, ISISEMD platform deploys a pure Service Oriented Architecture (SOA) that ensures the service integrity and the extensibility of the platform.

Service level agreement (SLA)-based web service infrastructures are the key for driving automation and system dynamics for ISISEMD platform. Web Services Distributed Management (WSDM) specifications and Web Services (WS)-Management only support a crude description of consumer-centric Quality of Service (QoS) properties not suitable to fully describe ISISEMD application requirements. However, the main challenge for ISISEMD is the specification of a QoS at the various levels in the value chain, including the ability to translate of high-level business objectives to low-level resource provisioning policies. Furthermore, well-defined metrics need to exist at all levels to allow monitoring and reporting of service usage against SLAs.

ISISEMD applications necessarily involve a network of services for their implementation. The application workflows involved, including both data and control flows, can be complex and require explicit support for e-care aspects and constraints.

The use of workflows for "programming in the large" to compose web services has led to significant interest in a standard workflow language within the web services stack. WS-BPEL (BPEL) has major industry support and was created through the agreed merge of their earlier web service composition languages WSFL and XLANG respectively. WS-BPEL and is

being promoted as a standard through OASIS (BPEL). The work of the workflow management coalition WfMC (WFMC) with the resulting XPDL standard (XPDL) provides a higher level of abstraction of workflow and aims to provide a format for process design. The focus of BPEL, and most business-oriented workflow languages, is control flow. Extensive research on workflow control patterns has shown that all languages have limitations in terms of what can be easily expressed (AALST, 2003). This insufficient expressivity and lack of rigorous semantics to allow automated checks on correctness and completeness mean that BPEL and related languages are unlikely to be a suitable foundation for ISISEMD.

The scientific community has also conducted considerable research into information and data processing applications that have similarities to some of the ISISEMD applications. However, these languages and tools do not support the constructs needed in ISISEMD and are not designed for Business to Business (B2B) applications that require distributed management, and trust and security based on the emerging industry Web Service standards.

Beyond this, comes research into intelligent, autonomous, goal-oriented and knowledge-based service infrastructures. These infrastructures include facilities for: dynamic negotiation, adaptation and configuration; intelligent scheduling, resource and service selection; and optimised job execution and management. The infrastructure itself is able to decide on how to react in case of unexpected situations using self-organisation, self-management, etc. Of particular relevance to ISISEMD is the use of semantic service descriptions to facilitate autonomic discovery, composition and use of services, for example within an organisation as an approach to resource management.

ISISEMD makes heavy use of emerging web service standards, including the areas of semantic service descriptions, SLAs and agreements, workflow and orchestration, management, trust and security, and transport and messaging. A significant research element of the work includes determining exactly how to apply and extend these standards in order to support ISISEMD applications. A particular challenge is balancing the use of industry standards, which are the key to meeting business to business needs and hence exploitation of the ISISEMD results. The standards that ISISEMD consider and engage with are manifold. Competing proposals from industry vendors may eventually converge through consolidation, but whilst this has the potential to improve interoperability, it often does so at the expense of compromising the specification.

In particular, ISISEMD adopts WS-Convergence where possible and evaluate/build upon/adapt the standards used for management, in particular to enable distributed management of networks of services that deliver real time applications in inter-organisation value-chains. Moreover, it uses Simple Knowledge Organisation System (SKOS) and Web Ontology Language (OWL), for formally describing SLA terms and their relationships, including QoS attributes of e-care applications. In particular, we address the problem of mapping high-level business objectives to low-level resource provisioning policies in a more automated, robust and verifiable way.

4.2 Potentials of ISISEMD services and limitations

Summarising the key features and comparing them with the existing solutions available in the market, ISISEMD service platform has the following advantages:

- Different levels of interaction and easy interactive features, allowing the elderly to ask for contact&help, confirm actions, play cognitive stimulation games, receive video calls
- Highly customized and targeting all user groups involved in care provision for a person with mild dementia or cognitive impairments and the person himself
- Integrated system with open architecture that can be easily extended with new features in the future
- Focuses on mild dementia persons in a holistic way, looking at all their needs (home and person safety, promote independence, prevent social isolation, increase quality of life, etc)
- Maintain or increase quality of life not only to persons with mild dementia, but also for the relatives who suffer care stress and are also socially isolated because of caring for the dementia relative
- Able to offer additional services with disease progression

On the other hand studying the competition, following points have to be considered:

- An end-to-end service approach should be addressed, so that this solution can be easily deployed. That includes: helpdesk, formal and informal care-givers, technicians, all accessible through a single entity
- The "breakeven" requires a large number of installations in order to have affordable service cost

5. Pilot operation and user evaluations

The pilot operation activities started with final testing of the integrated platform and the beginning of the real-life pilot operation. During 15 months (May 2010-August 2011) the pilots were used by the test users under realistic conditions – older adults in their homes; the professional care-givers in their work tasks, performing their daily work to care for the elderly; the informal care-givers/family, also in their everyday activities to care for the seniors. The services were first tested in a smaller scale, with a few end-users at three of the pilot sites for a period of 3-4 months, in order to identify if any major problems exist before the large scale testing with all users during the rest of the testing period. Small scale pilots were carried out in all of the regions, except in the region of Trikala, with 2-3 home installations in each of the regions.

Since the launch of the services, in three of the regions demo-rooms have been installed and in the fourth region the system was installed in the home of one of the formal care-givers. The demo-rooms existed in addition to the home installations and had the following goals:

- Demonstration of the services to potential test participants and their relatives – they were able to see, and experience the system before deciding to join the controlled study and were convinced that it is very user friendly and also aesthetically acceptable
- In these demo rooms, the formal care-givers were able to try in reality the system and provide final feedback to technical partners for usability and functionality and suggestions for improvement
- Potential end-users were introduced to the services and training was provided to them
- Personnel from care-giver organisations gained hands-on experience with the services and became more confident in usage of the system and learnt how to report technical problems

- Last but not least, the demo rooms were used as living labs because the improvements of the services were carried out in parallel with the pilot operation and in all cases the improvements were first applied and proofed in the demo machines, and then transferred to the home installations of the test users

In August 2010 the partners had a meeting to discuss experiences from the small scale pilot operation and how to make the transition to the full scale pilot operation more efficiently. In this way, the full pilot operation started in September 2010 and continued until the end of the project (August 2011).

To evaluate the effects of using the services in real-life, we followed overall assessment framework and carried out 15-month controlled study in the four European regions involving 71 elderly, 71 informal care-givers and around 15 formal care-givers, assessing baseline and final status of cognitive impairments, daily functioning and quality of life of the older adults. For the informal care-givers, quality of life and care stress were assessed. In the end of the controlled study, all groups were asked to evaluate their satisfaction and acceptability of the ICT services and their importance for care; the potential to promote independence and to increase feeling of safety. In three of regions, except in the region of Frederikshavn, the trial participants were split in intervention and control groups.

Significant results from the pilot operation were achieved even though the roll out of the pilots was more complicated than initially anticipated. There were a number of challenges to be addressed during the real-life pilot operation; some of those were not dependent on the consortium. The partners worked together and in many cases they were resolving technical issues in non-working hours/days based on good will and because of the eagerness to achieve a high impact. The whole process has been a positive learning experience for all of them.

The fact that most of the test users and their relatives are satisfied, feel safer and confident with ISISEMD services, is a significant result that is not measurable. Even somehow sceptical in the beginning, after giving them time to get used to the services, the elderly and their relatives accept the technology and can see the opportunities for positive impact. The relatives can better feel the difference by using the services in comparison with the elderly, because due to the disease, it is difficult for the elderly to think abstractly and understand it.

6. Outcome from technical evaluations - non-functional aspects

Technical evaluation was carried out to determine whether the system requirements were fulfilled by testing the services after the components of the system have been integrated into one system. The system evaluation had two aspects: *Functional evaluation* and *Non-functional evaluation*. The purpose of the *functional* tests were to evaluate all the functions that were enabled with the ISISEMD system. The *non-functional* evaluation included aspects such as e.g. scalability, reliability, flexibility. Non-functional requirements were validated based on qualitative and quantitative appropriate measures. More details about the overall assessment framework are presented in (Mitseva, 2010). In the next paragraphs we focus on the non-service specific evaluations which assess the readiness of the system for wider deployment.

6.1 Personalisation/customisation

Overall, personalisation/customisation features of the services were highly appreciated by the regional care providers and the end-users because they give possibility for them to map precisely the services to the exact needs of the dyad "elderly-informal care-giver" and fitting the support services in the care-giving and coping strategies.

6.2 Robustness of the equipments and connectivity

Carebox: we experienced some issues with the Touch-screen computer due to high touch sensitivity and they have been resolved by context-aware solution. Some few cases related to hardware failures that required replacement of the computer were mainly due to the fact that such device has been designed in "consumer electronic" segment that is not intended to run 24x7 in highly reliable environment. Unstable internet connections were reasons for false alarms and freezing of Carebox screen but they were alleviated by applying more sophisticated filters on bypassing false alarm triggering conditions.

GPS device: we used a simple GPS device called Lommy that is in general very robust and has been already in use in different contexts. The only few issues were the connector for charging the Lommy as it was difficult for use by elderly people; LED indicators, blinking with different colours, were confusing for the elderly and their care-givers; in two of the regions, that had hilly and mountain landscape, problems with the coverage were experienced.

Sensors and RAck MOnitoring System (RAMOS): The type used was Ramos Mini C. It is a very robust device. It is meant to be used both in home and industrial environments. The only one issue was Ramos and Ethernet failures during the installation and then fixed in the installation process. Overall, the problems with RAMOS and sensor devices were related to setup, configuration, placement, and installation, which is more about practical issue than the robustness.

Overall, the equipments to be used when offering ICT services for home support to elderly must be robust and "invisible" i.e. placed in those areas of the home where they are difficult to reach. This will prevent un-wanted disconnections or damages due to some every day activities such as cleaning, dusting, etc. It is best if the wires, RAMOS, routers are hidden in or behind cupboards or in a box. On the contrary, it is best if the Carebox (the Touch screen for the end users) is placed in a kitchen or living room or close to a TV, to make it easer for the elderly to see it and refer to it. It is even more important the equipments and the integrated services to be extensively tested in conditions as close to the real-life operation as possible before installing it in the homes. In this way, specific local issues can be discovered and eliminated. For example we experienced some hardware problems in only one region that were not common to the other three regions.

6.3 Scalability

During the ISISEMD pilot operation, it has been shown that the current architecture of ISISEMD portal and X-Server have been able to handle between 30 and 40 end users concurrently. In the future, it would be good to study and make some prediction on ISISEMD's users growth and traffic volume, such that network dimensioning and simulation can be done, and finally to decide the best network architecture.

6.4 Response time

During the pilot operation, response time metric is highly related to the services that activate alarms, especially alarms through SMS which is very much dependent on the network operator and SMS service provider. In the beginning of the pilot operation, the SMS service was assigned to normal level but since we observed delays in the delivery, the SMS service level was changed. The problem related to SMS service has been solved by subscribing to highest (and more expensive) service level of the SMS service provider.

6.5 Integration/openness

Integration of new hardware (especially sensors), requires some testing period in order to get the correct information reading as expected, e.g. by configuration and correct placement.

Integration of new software modules both on server and client side have been easily done in ISISEMD system since the platform has been designed in such a way that the services provided to end-user can evolve by providing API (Application Programming Interface) to service/software developer.

6.6 Manageability/flexibility

The assessment of ISISEMD system for these two parameters show that the platform is very easy and flexible to manage, i.e. in terms of adding/deleting new users, new services, new home installations, and new regions/sub-regions, etc., since it has been designed to support all these requirements. Furthermore, a user manual book written in four different languages (English, Finnish, Danish and Greek) has been provided as a guideline to regions and end users in general.

7. Outcome from service validation of the common functionalities of ISISEMD platform

We would like to argue for having carried out a good piece of work, overcoming a number of challenges, and that the final services meet the user expectations and acceptances at a high level supported by the outcome of the user evaluations. Overall, the care-givers were satisfied with the services and consider them important for providing care. Most of the users now state their wish for continuing to use the services after the project end. As suggested by the user feedback, there is even stronger need for service personalisation so they can function in a more intelligent and autonomous way.

Based on the continuous user feedback during the pilot operation, the services were improved where possible. But due to the limited project lifetime and resources, not all additional features suggested by the end-users as improvements could be implemented. However, they can be used for further development of the service platform as a commercial product. Subsequently, we emphasize on some of the suggestions that can be considered as **"wish list for the commercial system"** by the regional partners and by the test persons. We are of the interpretation that the following suggestions could improve the intelligence of the service platform in the next version of the system.

7.1 "Wish list" for enhancements for the commercial system

They were related mainly to higher intelligence&personalisation, improved usability and additional services.

7.1.1 Services enhancement for higher intelligence&personalisation

For the purpose of better personalisation, the free text reminders on the Carebox are suggested to be enhanced so they can contain longer text and, with advantage, to make it possible for the elderly him/her self to create their own text reminders, if the elderly is able to do it. It would also be an advantage for the users if the system is able to atomically create voice files for these free text reminders through speech synthesis. The reminders functionality can also be enhanced with more pre-defined reminders and advanced by having additional services such as shopping list reminders for the elderly people.

Other suggestions for enhancing the services and their usability concern implementing even more intelligence into the platform for automatic synchronisation of the calendar service events with the service for home presence. And for the cooker service, it would be an advantage to make separate time settings for the cooker plates and for the oven seeing that users have individual patterns and the oven shows to be used for a longer time than the cooker plates are. Users also suggest for the functionality of the intelligent front door service to be able to work without the bed sensor because there are cases when bed sensor cannot be used.

Further enhancement of the services is to create the possibility of having a small message board on the Carebox that can show to the elderly a SMS message sent by their care-givers mobile devices. In this way, the relatives will be able to send a SMS to the Carebox so the SMS text can be shown on the screen to the elderly person.

7.1.2 Usability enhancement

Some of the first suggestions focused on enhancing usability of the services, the portal and the Carebox - for instance, improving the visual aspect of the portal and the Carebox for enhancing the user interface to be usable by visual, hearing or cognitive impaired users. This will also create the possibility for other people with disabilities (blind/ deaf) to interact with the system.

7.1.3 "Entertainment" features

For the purpose of enhancing satisfaction of the elderly people and their family caregivers, it was suggested to include "entertainment" features - plug-ins for facilitating distribution of relevant information such as local news, the weather forecast, favourite music, etc. These entertainment features are to be accessible and shown on the Carebox screen by assigning for such a service.

7.1.4 Reflections

The automation degree of the services, together with their availability, was seen as a key feature for the family care-givers. Informal caregivers are willing to have very few degree of

interaction of the user with the system. This is mainly due to the fact that they understand, on the one hand, that elderly is not able to be familiar with the new technology and on the other hand, they are willing to increase the level of independence of the elderly but without the cost of adding more stress to their daily responsibilities. In addition, elderly cannot handle a lot of interactions with the system, since they are not familiar with the new technology and have somewhat of an aversion to learning. We have also seen that this may discourage use of the system, as the elderly may worry that they will break the technology, so they would rather not use it at all than be the cause of expensive repairs. The users want the system to be as automatic as possible; however, they also want inexpensive technological solutions.

7.2 Future work

Future work on the service platform can go in several directions. With respect to the technical side, it comprises mainly on implementing some of the suggested by the end users enhancements of the user interface of the Carebox and the portal. With respect to functionality, it can involve adding new services and enhancing the functionality of the Lifestyle Pattern service to automatically generate (graphical) reports for deviation from normal user behaviour. This service has also potential for improving quality of care for the formal care-providers and saving them time.

With respect to the services support, efforts can be dedicated to offering the services as one complete home-support service including acquiring the equipments, making the home installations, ensuring help-desk support, training the end-users, maintaining the services, etc. For user support, uploading short tutorial video-clips on the web portal for re-enforcing the training process for service setting was a suggestion by the regional partners.

For optimising the installation process, a direction to go is preparing installation software package with all needed settings and defining "a standard service package" in each region with the most desired services that will be initially offered to all elderly who subscribe to the home-support services and further re-assessed and updated if needed.

Taken as a whole, wide scale testing with higher number of test participants, more European regions and for a duration of a couple of years would show delay in institutionalisation and provide more real-life assessments of the services.

8. Results from the controlled study

8.1 Important aspects of the piloting process

Developing and piloting ICT services for older adults with cognitive impairments or mild dementia and their family care-givers has been a challenging process. A system like the ISISEMD platform is complementary to the daily support provided by the family care-giver and the relative itself is considered a user of the system. In addition, spouses/partners and closest family played a key role in the level of independence of old people with cognitive impairments or mild dementia and also in ISISEMD pilot. In the process of piloting the ICT services, diverse aspects played an important role – such as trust towards technology, complexity of installations and the platform due to the fact that it included high number of services. It is natural for this elderly user group to feel scepticism towards the technology

and we took this into consideration in the process. There was a thin line and a trade off between testing the platform with real users while the services were still under improvement and adaptation for the real-life conditions. Finding many volunteers who fit the inclusion criteria and are willing to evaluate the services was another challenge for us. It also took us time to build understandable communication in cross-disciplinary teams because of the different paradigms for the regional and technical partners. By far, the most crucial factors were proved to be the maturity of the services; the thorough testing before installing them in the homes; matching the services to those clients who have the most benefit from them and openness for new technology.

During the trial period, all ethical rights of the citizens were respected and the trials were carried out according to high ethical standards and the national regulations and the privacy of the trial participants and all data related to this were ensured. All applicable national and international laws and acts were respected too. The trial participants were recruited only after approvals from Ethical Committees were granted for each region where it was required and consent forms were signed by all trial participants.

At baseline, for the cohorts combined (intervention and control groups), the female participants were 67.4%, the average age was 78.69 years, having mild to moderate decline in cognition. The assessment on basic daily functioning showed full or high dependency, while instrumental activities of daily living mean score indicated mid-range of dependency. The test group of informal care-givers showed severe effect on their quality of life, but the mean value for cohorts combined was on the border line of severe effect on their quality of life. The care burden indicated that the care-givers were in the mid-range of caregiver-burden effects. Highest percentage of family care-givers was children.

8.2 Findings from the final assessments

The controlled study assessed in the end of the 15-month trial period cognitive decline and daily functioning for the elderly persons. For the informal care-givers – care stress. For both groups the impact of the services on the quality of life was investigated. We looked further into domains of which we expected the technology services to make a positive impact. Elderly persons and relatives were also asked for their willingness to use the services after the end of the project and their willingness to pay for the services in general.

User acceptance and satisfaction with the services were evaluated upon with the three main end-user groups and for instance, care-givers were asked about the importance for care and ability for independent living and, overall satisfaction. We observed a difference among the views from the four regions for the services showing a minimum/maximum satisfaction and acceptance among the elderly test users and a difference in the lowest/highest rating among informal care-givers of the services that are important for care giving. This also reflected cultural and care-model differences among the four European regions.

Regarding the feeling of safety, 70% of the elderly felt safer when using the ISISEMD system. Another 20% reported feeling significantly safer. 40% of the informal care-givers report feeling safer, with another 50% of them reporting feeling significantly safer. More than half of the test users reported independent living increases - 51.61% of elderly and 67.74% of informal care-givers. Also 3.23% of the informal care-givers reported it increases more than they thought.

According to the test group's final evaluation, there was a significant decrease of the level of care burden among the informal care-givers after using the ISISEMD services whereas in the control group the informal care-givers burden indicated an increase after the evaluation period. Overall for the test group, 80% of the elderly maintained their basic Activities of Daily Living (ADL) and 40% of the elderly improved their Instrumental Activities of Daily Living (IADL). For the Quality of Life, 70% of the elderly had an improvement in their Quality of Life and 80% of the informal care-givers similarly had an improvement in their Quality of Life. 80% of the informal care-givers had a reduction of care-related stress (care-giver burden) and 0% had an increase in care-related stress.

8.3 The view of the formal care-givers

From formal care-givers point of view, at least two thirds of formal care-givers rated the services to be easy to use. In extension, the majority of formal care-givers rated the services to be very important for care. They felt that services were easy to integrate into their existing care routines and were easy to personalise. Three quarters of formal care-givers also provided high ratings for services, in terms of their importance for care-giving.

From the qualitative evaluations, we can draw the conclusions that parameters that were important along the way for piloting the services were service maturity, flexibility and personalisation. Furthermore, the training of the end-users and the intelligence of the services played an important role for the overall satisfaction too, platform stability and service availability and offering the services at earliest stage of the disease.

8.4 Acknowledgements for the test users in the pilot

We would like to thank to our test users whom we accept as an equal partner of the consortium. They played a very important role in the process of bringing the services to a mature level and improving them in all aspects in order to meet their needs as best as possible. We can confirm that it is of high importance that the primary user and care-givers are to be motivated towards the usage of aiding technologies in their homes. For the acceptance of the services by the elderly, a key role was played by the family care-giver and the process was much more rapid and easier if the care-givers had previous experience with technology.

9. "Success stories" from the pilot

The positive impacts from the use of the services are described below with the words of the real users as success stories and the overall interpretation of these, points towards an improvement in feeling of independence and safety and in communication and social relation between the elderly people and the relatives. Thus, an improved Quality of Life is being observed in reality.

ISISEMD services form a basis for good communication between the elderly and their relatives. Hence, the services help the elderly people with mild dementia in the North Region of Denmark to create quick and easy communication with relatives. The Carebox equipped with a help button, is helpful for the elderly in the sense that it is easier to get in touch with relatives whenever it is needed, emergency or not. One case showing the

advantages of the ISISEMD Carebox comes into play due to the fact that one elderly with dementia has difficulties to make phone calls to relatives. Instead, by pressing the Carebox help button, the elderly person can easily get into contact with relatives. Contact is simply generated automatically by the system with the help of an SMS that is sent to relatives when the elderly presses the help button.

The outdoor safety service helps the elderly people with mild dementia to stay healthy by giving them the possibility to be active outdoors in their everyday lives. One case with an older man from North Region of Denmark reveals the advantage brought by the GPS device. The older man with diabetes who needs to keep his blood pressure down used to be afraid to go outside, as he could get lost. Today, with the GPS device the older man is no longer afraid to go for a walk. He explains, *"I feel more safe because I know that the Lommy will help me to get in contact with my family and then, they can find me if I get lost"*. Neighbours and relatives reveal that they have even observed that the older man is going regularly for walks and that they can see his position on a map if he needs help or gets lost.

Intelligent door alarms prevent the elderly people from leaving their homes unnoticeably in the winter time - In Finland, a relative explains the significance of ISISEMD Intelligent door alarm and the impact it has done on both her mother and her self. The relative explains that now she can prevent her mother from going out of the house and getting lost in the cold winter in Finland. The Intelligent front door service sends an alarm message to a relative informing that the door opens and thus, the older person might be leaving the house. According to this, a relative has stated: *"In Finland, this service is very important so that we can be informed if our relatives get lost. It is so cold in the winter and this can be dangerous if the elderly goes outside for a longer period of time".*

Bed sensor helps the elderly to alert their families automatically when help is needed during the night - In Finland, a relative expresses the importance of having a bed sensor installed. The relative explains that her mother has had several incidents of falling down from her bed during the night. The bed sensor sends a signal when an elderly is out of bed for too long, thus a relative or a caregiver will receive an SMS with the alert. In this particular case, the relative explained… *"When I received this message, I went to my mother's house and found her on the floor. I am very happy to have received this SMS so that I could help my mother, even if it was in the middle of the night".*

ISISEMD Calendar and To Do List, shown on the ISISEMD Carebox, helps the elderly with mild dementia to live more independently - With the ISISEMD Carebox the elderly can keep track of the day and time. For instance, in North Ireland, a relative living with her mother states: *"Even if we only have had the Carebox for 10 days, both my mother and I already feel a difference. Normally my mother always calls me several times at work every day being anxious about not knowing the day and time. Now, with the Carebox, my mother is always informed about the day and time and this has helped her to become more confident. "*

ISISEMD services are beneficial for enhancing the quality of life of the elderly and their relatives - In Greece relatives taking care of the elderly explain that the services help them to feel safer knowing that their parents have the ISISEMD services installed in their homes. Hence, relatives are aware if the elderly leaves their houses or if they are out of bed for a long time. One relative explains … *"Before having the ISISEMD services we had to travel 30 minutes outside of town every day to check on our relative. Now we feel safer knowing that our*

relative have the ISISEMD services installed and our relative can keep on doing everyday activities and plan their days, independently. "

10. Conclusion

ISISEMD platform with innovative intelligent services is scalable, open-system, validated in real-live environment. The competitive advantage of ISISEMD systems is that it is based on a modular scalable open platform that advances the State-Of-the-Art in the areas of systems for Ambient Assisted Living and can be integrated with other Health or Care Systems. Additional services can be included anytime, resulting in a very powerful platform system.

Last but not least, ISISEMD services have been extensively tested and validated in a pilot operation with 142 end-users (71 elderly and 71 relatives) for 15 months in four regions - in Denmark, Finland, Greece and UK. The final user evaluations, carried out in June 2011, showed high level of user acceptance and satisfaction with the services and willingness to use them after the project ends.

We knew that sceptical users are stoppers against introduction of new technologies. But our experience shows that the elderly and their relatives accept the technology and can see the opportunities for positive impact and added value from the use of the services in their everyday life even when the older adults with mild dementia and their family care-givers were sceptical in the beginning, after giving them time to get used to the technology. It can be expected, that after about one month, the elderly and their family caregivers can get used to the services. The most successful adoption of the services can happen when they are offered as early as possible in the disease. In this way, the technology services can be integrated in the coping and care strategies in the family and elderly has highest chances to learn to refer to the services.

The benefits from using ISISEMD services were depicted in the user acceptance surveys, contributing to the Quality of Life of the end-users. The services improved the elderly ability for self-care by support for their basic daily activities in way that prevents health risks in their homes and promotes independence. They strengthened the daily interaction with their social sphere - partners and relatives, giving them the feeling of safety and improving their relationships. For the family care-givers, the services increased their quality of life and the feeling of safety; reduced their care burden and gave them a piece of mind while saving them time and money.

Potential for direct savings from the usage of the ICT services is foreseen for both the care-provider organisations and informal care-givers. Costs can be saved from time and travel expenses for delivery of warm meals to elderly, performing on-line sessions with use of video-call service instead of physical home-safety visits, visits for administering medications, automatically registering information for such services, etc. The informal care-givers can save time and money for making telephone calls to elderly to check about status or to drive to elderly place or to cook meals for them. The highest potential for savings is at a society level - with delaying the admittance in nursing or dementia care institutions where savings at European level can range from approx. 1300-4000 euro for one person for 12 months.

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12. Disclaimer

This paper reflects only the views of the authors and the European Commission is not liable for any use that might be made of the information contained therein.

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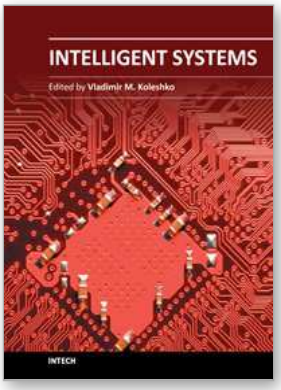

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This book is dedicated to intelligent systems of broad-spectrum application, such as personal and social biosafety or use of intelligent sensory micro-nanosystems such as "e-nose", "e-tongue" and "e-eye". In addition to that, effective acquiring information, knowledge management and improved knowledge transfer in any media, as well as modeling its information content using meta-and hyper heuristics and semantic reasoning all benefit from the systems covered in this book. Intelligent systems can also be applied in education and generating the intelligent distributed eLearning architecture, as well as in a large number of technical fields, such as industrial design, manufacturing and utilization, e.g., in precision agriculture, cartography, electric power distribution systems, intelligent building management systems, drilling operations etc. Furthermore, decision making using fuzzy logic models, computational recognition of comprehension uncertainty and the joint synthesis of goals and means of intelligent behavior biosystems, as well as diagnostic and human support in the healthcare environment have also been made easier.

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